Non-Destructive Thermal Diagnostics of Porous Materials

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Transport thermal physical properties such as thermal conductivity and thermal diffusivity vary with temperature, and gas pressure in a complicated way. Predominant factors that along with temperature and gas pressure affect thermal conductivity of porous ceramics and other materials are discussed. These factors include porosity, geometric parameters of pores, cracks and grain boundaries. A physical-mathematical model for calculation of thermal conductivity of composite porous materials is described.

Developed mathematical models of apparent thermal conductivity of porous materials are applied to non-destructive methods of thermal diagnostics. The non-destructive thermal diagnostics of porous materials enables to estimate pore and crack sizes in the range 10^{-9}-10^{-3} m. Fractal models of porous structure and dependencies of thermal conductivity/diffusivity on (experimental) gas pressure are used as a basis for structure parameters calculations. The measuring element (sensor) in this method is, actually, the free path of gas molecules in pores and cracks (Knudsen number) depending on gas pressure.

Possible applications of the developed methods include non-destructive thermal diagnostics (NDTD) of the of nano- and micro-crack sizes; opening, closing and size changes of the cracks at high temperatures in a wide temperature range; evaluation of interfacial and contact heat barrier resistance for coatings; remote laser thermal diagnostics of the cracks; strength, failure and fatigue analyses.

Examples of several applications of the NDTD method are presented.